Commercial production of 'Frontenac' grapes in greenhouses

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Executive Summary

The production of greenhouse grapes is a very uncommon but historic concept. Although rarely found, *Vitis riparia* 'Frontenac' would be a good cultivar for greenhouse production due to its large resistance to root *Phylloxera* and winter hardiness. For these reasons, winter costs of a greenhouse would be lower than those for other crops that are harvested year-round. Greenhouses would have better protection from other pests that affect 'Frontenac' grapes in the vineyard, such as leaf *Phylloxera* and *Botrytis*. The following paper goes to explain why growing 'Frontenac' in greenhouses would be both cost-efficient and sustainable.

1. Introduction:

A. Study species: *Vitis riparia* 'Frontenac'

The University of Minnesota (U of M) initially crossed the 'Frontenac' grapevine in 1978 and then selected the seedling vine in 1983 to continue growing. In 1996, after almost 20 years of breeding, 'Frontenac' was the first cold hardy grape introduced to the public. It is a cross between the French hybrid Landot 4511 and a very cold hardy variety of *Vitis riparia* 89 that was found growing in the wild near Jordan, MN (Univ of Minn, 2014; Wikipedia, 2015). The vines very vigorously produce clusters of dark, high-sugar, high-acidity berries. They are cold hardy to below 0.6C and highly resistant to powdery mildew and botrytis and nearly immune to downy mildew (Univ of Minn, 2014; Wikipedia, 2015). 'Frontenac' is a challenge to winemakers in that they have highly acidic berries and unusual pH levels (Wikipedia, 2015). The wine has aromas of cherry and other red fruits in the production of red wines, rose, and port (Wikipedia, 2015).

The goal of this paper is to explain how to grow *Vitis riparia* 'Frontenac' at a greenhouse production scale. There are many difficulties in growing 'Frontenac' in a greenhouse, and this paper is meant to touch base on them all.

B. Taxonomic Classification and Geographic Distribution in the Wild.

Vitis riparia 'Frontenac' is in the Plantae Kingdom (USDA, 2010). It is in the Order Vitales and the family name is Vitaceae (USDA, 2010). *Vitis* is the Genus name and *riparia* is the species (USDA, 2010). A couple common names for this grape cultivar are frost grape and riverbank grape (USDA, 2010). The 'Frontenac' grape is found in Canada in New Brunswick, Nova Scotia, Ontario, Quebec, Manitoba, and Saskatchewan; and in the United States in Connecticut, Indiana, Maine, Massachusetts, Michigan, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, West Virginia, Illinois, Iowa, Kansas, Minnesota, Missouri, Nebraska,

North Dakota, Oklahoma, South Dakota, Wisconsin, Alabama, Arkansas, Delaware, Kentucky, Louisiana, Maryland, Mississippi, Tennessee, Virginia, and Texas (USDA, 2010).

II. Crop History

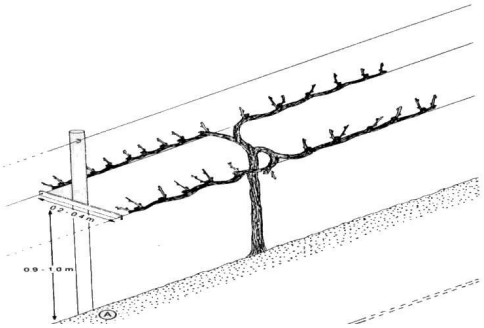
A. Breeding & Domestication

'Frontenac' is now the most widely planted red-grape vine in Minnesota and is found throughout the Midwest, New England, and Quebec (Univ. Minn, 2014). It is able to grow in USDA plant hardiness Zones 4 and 5. Since this grape cultivar is a newer introduction to the plant world, it is not yet known if it is invasive. Both parents of this grapevine are not invasive, so only time will tell; 'Frontenac' is not expected to be. The U of M mostly uses a high cordon (HC) training system for the grapes that they breed (Figure 1) (Univ. Minn, 2014). This allows for a smaller number of variables in their experiments; the HC training system can be described by a cordon that lies along the top wire of a trellis branching from either a single or double trunk that is positioned in the middle of the vine space (Zabadal, n.d.). A cordon is the "arm" or part of the vine that younger plant-growth grows from. Different experiments that could be performed could include trying different training systems for the Frontenac vine.

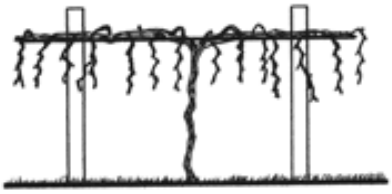
'Frontenac' has been known to live through winter temperatures of 0.6°C. This vine has also gone through experiments that tested high disease pressure and has been resistant to downy mildew, powdery mildew, and black rot. It has shown no signs of berry splitting or *Botrytis cinerea* (a fungus that may cause fruit to dry up and drop prematurely), but the leaves have been noted as susceptible to *Phylloxera* (a tiny aphid-like insect that feeds on the roots or leaves of grapes and can cause stunting of the vines or death) (Province of British Columbia, 2014; UC IPM, 2015). 'Frontenac' vines have a slightly upright growth habit with moderately high vigor

and arching canes. Several training systems used for 'Frontenac' includes Geneva Double Curtain, high cordon, and low cordon with vertical shoot positioning (Figure 1). The Geneva Double Curtain training system has two bilateral cordons that have a canopy that looks like there are two curtains on either side (Pago de Lorrainzar, N.d.). The low cordon with vertical shoot positioning training system has cordons that are within 15-30 cm from the ground (Zabadal, N.d.).

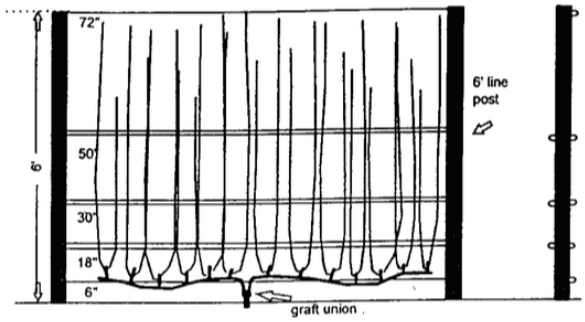
Figure 1: Training Systems for 'Frontenac' grapes (Pago de Lorrainzar, n.d.; Brown, et al., n.d.; Zabadal, n.d.).



A. Geneva Double Curtain



B. High Cordon



C. Low cordon with vertical shoot positioning

'Frontenac' is a midseason grape and has an average harvest date of September 25 in Minnesota. Shoots produce about 2-3 clusters and may need cluster thinning, especially on young vines. This grapevine produces high yields averaging 10.9 tons/ha. The loose berry

clusters are medium in size, about 17.8 cm in length, which are conical in shape and have berries that average 1.3 cm in diameter. Due to high levels of acidity and sugar in the 'Frontenac' grapes, the wine typically requires malolactic fermentation (a type of fermentation that occurs with making wine and makes the wine less sour) to get a well-balanced wine (Univ. Minn, 2014; Gawel, 2009).

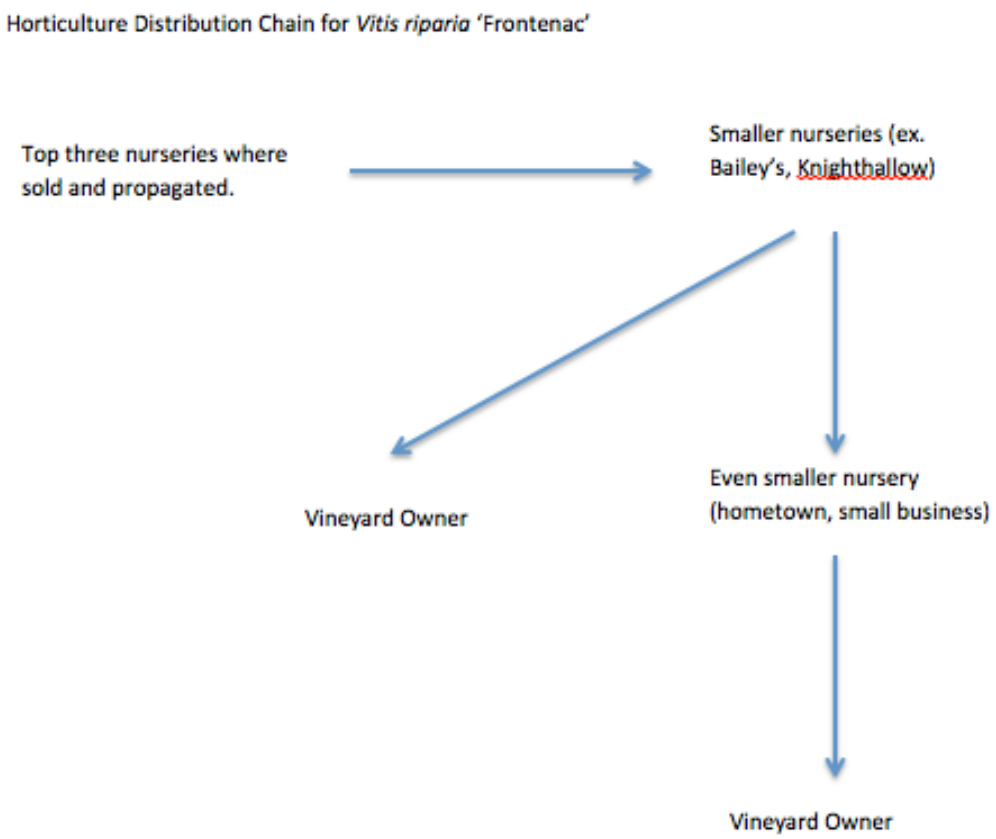
The U of M has an ever-growing grape-breeding program and has produced four award winning grape varieties, including 'Frontenac'. In 1943, Elmer Swenson, a farmer near Osceola, MN, began breeding French hybrid grapes with the native *Vitis riparia* (Wikipedia, 2015). This was the beginning of the U of M grape-breeding program. In 1969, Swenson began working for the University of Minnesota, taking care of fruit crops, although most of his breeding occurred on his farm (Wikipedia, 2015).

Today, the U of M is known to have one of the top wine grape programs in the United States (Univ. Minn, 2014). Considering that the 'Frontenac' grape has only been grown commercially grown and sold since 1996, there is not much history regarding this cultivar. However, its parents, Landot 4511 and *Vitis riparia*, have a little bit more history. Landot 4511 was brought to North America from eastern France in the 1950s and is considered a complex interspecific hybrid, which means that it has a long line of breeding behind it. It was used as a parent species because of its high disease resistance (Wikipedia, 2015). *Vitis riparia,* on the other hand, is native to Minnesota and is, therefore, known to be very winter hardy. It is also used as a rootstock for other grape cultivars, as the roots are resistant to *Phylloxera* (Wikipedia, 2015).

'Frontenac' is a seeded, very acidic cultivar and, therefore, would not be good for table grapes, whether they are seedless or not. Grapevines can be bought through a catalog or online. A nursery, commercial vineyard, or an average homeowner either buys these plants; but the

homeowner could also buy their plants from the nursery, as shown in Figure 2. (Rombough, 2002).

Figure 2: Distribution Chain for *Vitis riparia* 'Frontenac'



III.

Production Information

A. Current Production Practices

Grapevines that are bought online or from catalogs will be sent as dormant, bare root plants. Keep them in a cool place before planting and don't let the roots dry out; plant bare root plants as soon as the soil can be dug up. Before planting (spring planting is recommended), soak the plant roots in water for 3-4 hours. Then, remove all canes except the most vigorous, spread the roots

out into a hole in the ground, and plant with the lowest bud on the plant just above the surface of the soil. For potted grapevines from a local nursery, plant after the threat of frost is gone. Establish a regular watering schedule throughout the first year (Tepe, et al, 2015). Sandy loam is the best soil to grow grapes because it drains well and holds enough nutrients (Cochran, 2015). In a greenhouse, the soil type would be one of the easiest parts to manipulate. A pH of 5.5 to 7.0 is recommended for grapes, and good drainage is key (Cochran, 2015).

Figure 3: Production Timeline for Old and New Plantings (Tepe, et al, 2015)

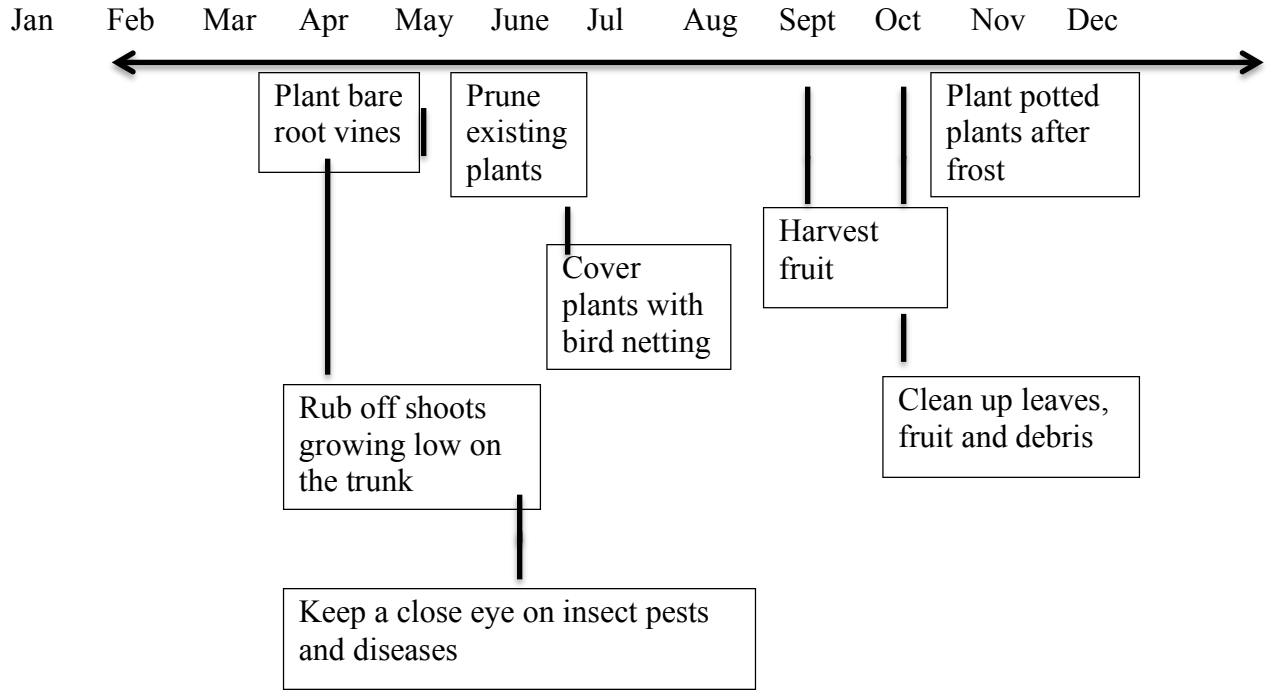
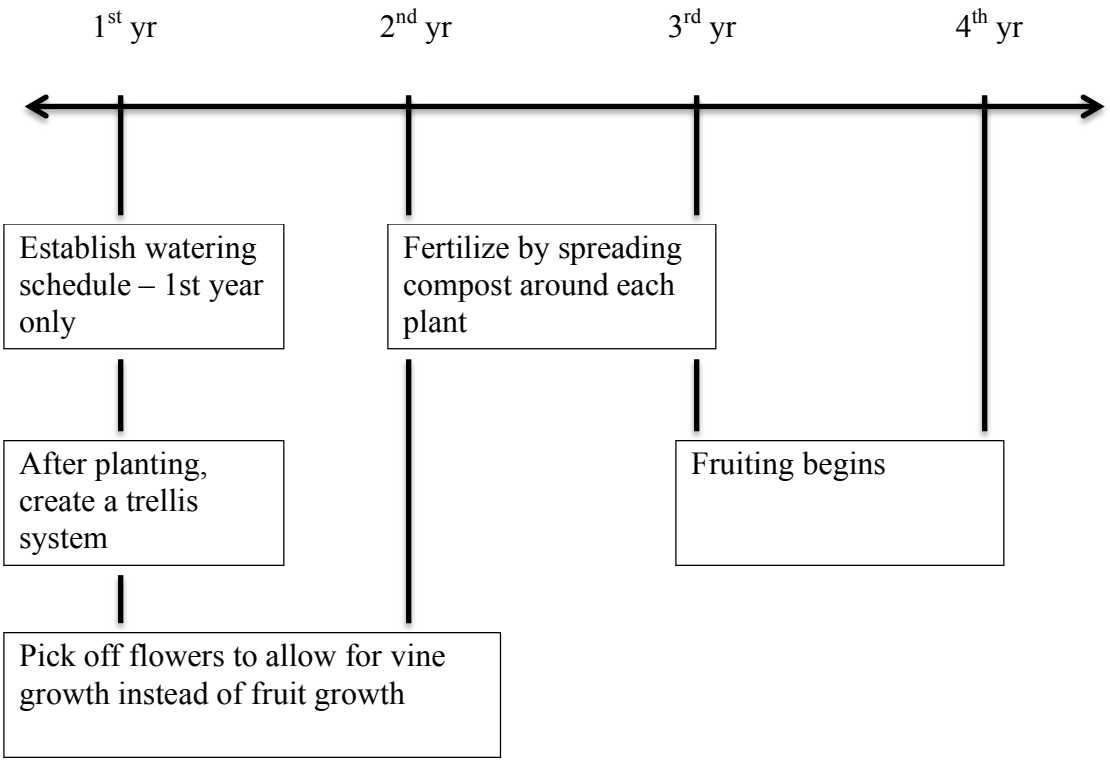


Figure 4: Production Timeline for First Four Years of Planting (Tepe, et al, 2015; Rombough, 2002)



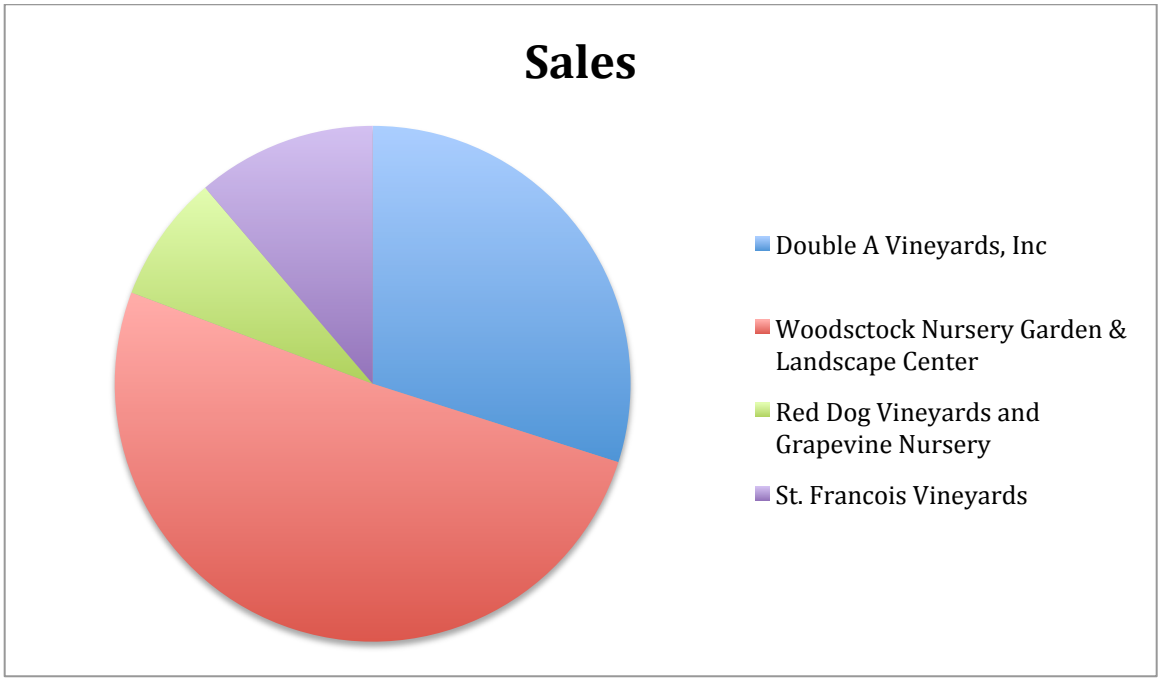
Since it takes a considerably larger amount of time to grow grapevines from seed, it is most common to take hardwood or softwood cuttings for propagation. However, after stratification (a period of time where seeds are exposed to cold temperatures to break down substances that keep the seeds dormant), seeds can be planted directly in the ground or in pots in a greenhouse. Figures 3 and 4 shows the production timeline necessary for growing grapes from cuttings. Harvestable fruit typically comes in the fourth or fifth year, so the first few years of growing are just to produce and maintain fruit. This may cause a problem with greenhouse production because there will be only output of money for these first years.

There is much research being conducted at this time to make grapevines more winter hardy and sustainable. If the production and sales of grapevines increased, there would be more cultivars available. However, with sales of these plants being mostly online and in catalogs, it is easy to access different plant material from different states. Because much of Europe has laws on the distribution of their plants, it is hard to purchase different plant material to and from other countries. Access to this plant material could help in the breeding aspect of getting desirable traits or the introduction of the next best wine or table grape.

B. Current Production Statistics

According to the Double A Vineyards, Inc. (Fredonia, NY) 2014-2015 catalog, the wholesale price for up to 24 bare root vines is $8.25 per vine. To buy between 25 and 49 vines, the price is $7.50 per vine; and the price of 50 or more vines is $3.05 per vine. Woodstock Nursery Garden & Landscape Center in Neillsville, WI is selling 'Frontenac' grapevine plants that are potted for $14 each. Red Dog Vineyards and Grapevine Nursery in Ankeny, Iowa is selling 'Frontenac' potted grapevines for $2.20 each. St. Francois Vineyards in Park Hills, Missouri is selling 'Frontenac' potted grapevines for $3.10 each. Figure 5 shows the price per vine from these four nurseries. The most expensive one ($14 from Woodstock Nursery) is a potted plant versus bare root (like the rest). For a large production of 'Frontenac' in a greenhouse, it would be a wise decision to buy bare rooted plants and plant them in a sandy loam soil.

Figure 5: Price Comparison of 'Frontenac' grapes for Four Different Nurseries.



The 'Frontenac' grapevine has many important qualities. One of the parent plants is a native grapevine to Minnesota and has winter hardiness and resistance to phylloxera that is very important in the grapevine industry, whether it is table or wine grapes. This cultivar would not make a very popular table grape; but, if bred with the right parent plant, could produce a seedless table grape with great taste, Minnesota winter hardiness and phylloxera resistance.

Phase III.

IV. Proposed Crop Transformation

A. Crop Production Changes for the Future

The next step in grape research could be to breed a cultivar that would be resistant to foliar *Phylloxera*. Using a resistant rootstock was the way to get rid of root *Phylloxera*, but the foliar type is still a problem. Powdery mildew can be a problem in vineyards, and breeding a cultivar

that is resistant to this disease can be a positive addition to the vineyard world. Another change to this crop would be to breed a cultivar that has less acidity. A big challenge with using 'Frontenac' as a wine grape is the high levels of acidity due to the high level of malic acid content. When the wine goes through malolactic fermentation, the malic acid content in most grape varieties will be highly reduced. However, 'Frontenac' does not reduce the malic acid as drastically, so the acidity of the wine is greater than other wines. A new cultivar could be introduced that has the great qualities of 'Frontenac' and the lower acidity of a different cultivar.

One of the biggest challenges for greenhouse growing is deciding whether or not there will be a big enough return, due to initial startup costs and the continual inputs. The initial costs include the price of land (depending on location/what time of year/which year), the cost of building the greenhouse, water/nutrients, electricity, labor, initial price of plants and additional plants if needed (due to disease/death). These factors all play into the price of growing any crop in a greenhouse. With 'Frontenac', these grapes won't be sold until the fifth year of production.

However, a higher price could be charged due to the fact that these grapes would be grown in a controlled area and are of higher quality and higher sugar content. This idea would work well to sell to amateur winemakers or home winemakers, because they are not making large quantities of wine; therefore, they would have more money to spend on better quality. Because of the higher price of the grapes and the smaller market, it would be considerably harder to sell. Another idea for greenhouse grape production would be to grow a table grape, such as *Vitis vinifera* 'Jupiter', rather than a wine grape. A table grape could be sold as Community Supported Agriculture Shares (CSAs) or at farmer's markets and would have a larger market with which to sell. For example, there is a winery, called Emerine Estates Winery, in Jefferson,

Ohio that is growing grapes in greenhouses for wine production. They have 14 greenhouses that produce 150 gallons of juice per year.

B. A New Production Schedule

The new production schedule will start with bareroot cuttings purchased by one of the top three biggest wholesale production nurseries for 'Frontenac' - Winterhaven, Double A. Nurseries and Northeastern Nurseries. These cuttings will then be shipped to a designated nursery (like Bailey's) that would pot them in 3" pots and for the first year. In the spring of the next year, the pots would be sold to the company that is going to grow 'Frontenac' for greenhouse wine grape production. **The plants will then be planted in the greenhouses, right into the ground. Because of the in-ground drip watering system, this will make it easier to manage nutrients and water. Also, the plants would have an unrestricted root zone, allowing for more plant growth.** That same year, a trellis system will have to be installed, and a watering schedule with the necessary nutrients will have to be established. For the first two years of greenhouse production, the buds will have to be removed to allow the plant to put more energy toward growing hardy vine growth. The buds will form in the fall of the second year, and buds break in spring following that fall (Dami, et al. 2006). In the third year, fruiting will begin; by the fifth year, there will be harvestable fruit. Fruit initiation begins in the summer months, usually beginning of June.

C. The New Crop Ideotype

The proposed idea for *Vitis riparia* 'Frontenac' is to grow these grapevines in a greenhouse. The controlled temperature, lighting and pest protection will allow for higher quality fruit. Because this crop will be planted into the ground and an in-ground drip-watering system will be used,

there should be higher yields as well. As discussed before, whether or not grape production in a greenhouse would be profitable depends on many variables, including initial greenhouse building cost, price per plant, labor, etc. As far as purchasing a quality crop, 'Frontenac' was breed here in Minnesota and should not have any problems with receiving bad plant material. There are no restrictions on getting the material, as it has been 15 years since the plant patent has expired.

Due to the cold hardiness of 'Frontenac', the greenhouses will have a lower temperature and cost will be less during the dormancy period in the winter. More research on prices of greenhouse and grape production at different locations would provide much needed insight as to whether or not growing grapes in a greenhouse would be cost-efficient.

V. Acknowledgements

I am truly thankful for the help of Professor James Luby from the University of Minnesota for his insight and information on distribution, greenhouse growing ideas and more for *Vitis riparia* 'Frontenac'. I would also like to acknowledge the University of Minnesota's Extension website for the background information on 'Frontenac'.

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